The construction cost behavior: a co integration application

Marcelo Miranda de Melo[1]

Abstract: The main goal of this research is to investigate the Brazilian construction cost behavior between the period of January/2008 and June/2013. The time series co integration and Granger causality approaches were applied. This academic work selected the following variables: average construction cost per square meter (R$/m^2), home credit (Millions R$), effective average income (R$), cement consumption (Tons) and construction materials sales (2011 = 100). Research data was collected from IPEADATA and SINDUSCON. The Augmented Dickey-Fuller Test (ADF) identified that all variables are not stationary in level, however all variables are stationary when integrated in first order. The Johansen Test identified that all tested variables are co integrated with average construction cost and in the Granger causality test income does not cause average construction cost. The key variable for construction cost behavior across the research period seems to be home credit. An initial raise in population's income has foster home credit availability that induced cement consumption and construction material sales. Home credit has forced an increase in Real Estate demand that influenced heavily in construction cost increases.

Key-Words: Construction. Co integration. Cost. Real Estate.

1 Civil Engineer (UFC), MSc in Construction Management (UMIST-U.K.), PhD in Economics (CAEN-UFC), Research Professor at Universidade Federal do Ceará (CAEN-UFC), Economics and Finance Professor at UFC, marcelomirandamelo@ig.com.br, marcelomelo@ufc.br.

Resumo: O principal objetivo dessa pesquisa é investigar o comportamento do custo de construção brasileiro no período de Janeiro/2008 a Junho/2013. Foram aplicados métodos de séries temporais e causalidade de Granger. Esse trabalho acadêmico selecionou as seguintes variáveis: custo médio de construção por metro quadrado (R$/m^2), crédito habitacional (Milhões R$), renda média efetiva (R$), consumo de cimento (Tons) e vendas de materiais de construção (2011 = 100). Os dados da pesquisa foram coletados no IPEADATA e SINDUSCON. O teste ADF identificou que todas as variáveis não são estacionárias em nível, porém todas as variáveis são estacionárias quando integradas de primeira ordem. O teste de Johansen identificou que todas as variáveis são cointegradas com o custo médio de construção e no teste de causalidade de Granger, a renda não causa o custo médio de construção. A variável chave no comportamento do custo de construção parece ser o crédito habitacional. Um aumento inicial na renda da população aumentou a disponibilidade de crédito habitacional que induziu o consumo de cimento e a venda de materiais de construção. O crédito habitacional forçou um aumento da demanda de unidades imobiliárias que influenciou fortemente o aumento do custo de construção.

Palavras Chaves: Construção. Cointegração. Custo. Imobiliário.

1 Introduction

The Brazilian construction industry has showed a relevant development since the American Crisis (2008-2009). The Great American Crisis seems to have deeply harmed expectations of financial market investors as a whole. In many ways, the real side of the economy, real estate seems to be a safe port for new investments. Gonçalves & Castelo (2012), estimated the increasing participation of the Brazilian civil construction industry in the Brazilian GNP from 2007 to 2011. This figure increased from 4,9% in 2007, before the American Crisis, to 5,8% in 2011.

According to SINDUSCON-RJ (2013), between early 2008 and middle 2013 the construction cost per square meter in Rio de Janeiro increased not less than 49,34%. In the same period of time this figure in Paraná was even greater, 52,88%, according to SINDUSCON-PR (2013). The greater participation of the Brazilian civil construction industry in the Brazil´s GNP apparently has forced also an increase in construction costs.

According to Brazilian Civil Construction Camber-CBIC (2014) Brazilian civil construction sector has growth over 11% in 2010 and was the economic sector that showed the greatest growth in that year. However in the following years, 2011 and 2012, this sector has showed a much more unpretentious performance with 3,6% and 1,4% of growth respectively. Even in 2011 and 2012, Brazilian civil construction sector was among the economic sectors that presented the greatest expansion.

Also according to Brazilian Civil Construction Camber-CBIC (2014) Brazil has a huge real estate deficit. This figure was estimated in 2007 the amount of 5,9 Millions unities and in 2008 the amount of 5,5 Millions of real estate unities. This statistics revels that the Brazilian construction industry has much space to growth into the economy.

The above numbers confirm the bearing of the civil construction industry and the real estate sector in the Brazilian economy. Moreover, there is evidence that this fast economic activity of these sectors have contributed to an augment in average around 46% of the construction cost per square meter of the real estate unities in the research region between early 2008 and middle 2013.

The foremost objective of this academic work is to investigate the behavior of Brazilian construction cost across the research period. As a secondary goal this research focus on macroeconomic variables that may interfere in the construction cost of the research region. Time series co integration methodology and Granger causality test were adopted in order to identify sustainable long term relationship between macroeconomic and the construction cost variables as well as cause-effect relationships. Which macroeconomic variables are relevant for the construction cost in Brazil?

This paper is divided into the following stages: beyond this introduction, presents selected researches in civil construction cost subject and its determinant factors in 2, the time series co integration and Granger causality methodologies are explained in 3, empirical results are presented in 4, specifically in 4.1 data collected, stationary and co integration results are presented. In 5 final remarks are addressed and finally in 6 all references are listed.

2 Civil Construction Cost Researches and Determinant Factors

Okpala & Aniekwu (1988) examined the causes of high costs of construction in Nigeria. They found that direct costs overruns are among the main factors leading to the high costs of construction. A questionnaire was designed incorporating factors causing delays and cost overruns. It was distributed to engineers, architects, quantity surveyors, contractors and others involved in construction. Results indicate that: high costs can be minimized by minimizing lapses in the management of labor and material resources, shortage of materials; methods of financing and payments for complete works and poor contract management are the three major reasons for high construction costs.

Somerville (1999) found that change in the level of residential construction affects macroeconomic conditions and is an important determinant of movements' in house prices. Moreover, his research states that increases in cost of construction should reduce the supply of new housing. However, empirical research has failed to find a reliable and consistent relationship between these costs and housing starts. Not less relevant findings are that housing starts are quite elastic, construction costs are endogenous in the new housing supply function and the cost shares of material and labor in the structure of new residences are approximately 65% and 35%, respectively.

Chan (1999) used the asset market equilibrium approach to investigate the impact of credit market imperfection in residential construction. A new speculative single-family housing starts series is developed for this analysis. The author concludes that credit-market factors appear to affect both the cost of construction loans and the price elasticity of single-family housing construction. These effects are especially strong on speculative housing construction.

Santos & Cruz (2000) analyzed the real estate market dynamics in special focus to the Great São Paulo. They conclude that the real estate market presents strong cyclic behavior, the elasticity of new home unities is unitary, interest rate have negative impact to real estate demand and finally income have strong correlation to real estate demand.

Koushki; Al-rashid & Kartam (2005) identified three main causes for cost overruns in Kuwait in a construction of private residential project. The main causes were: contractor-related problems, material-related problems and owner´s financial constraints.

Edelstein & Tsang (2007) developed and tested a theoretical model for residential housing market cyclical dynamics. The model employs an interactive supply and demand framework to engender housing price dynamics. Their empirical analyses suggest that fundamentals, such as employment growth and interest rates are key determinants of residential real estate cycles. An increase in construction costs will reduce the profitability of builders and reduce housing investments. Similarly, a credit crunch will limit the ability of builders to raise capital and will reduce housing investment.

Goodhart & Hofmann (2008) examined the links between money, credit, house prices and economic activity in industrialized countries over last three decades. The analysis is based on a fixed-effects panel vector auto regression, estimated using quarterly data for 17 industrialized countries spanning the period 1970-2006. The main results are the following: (1) there is evidence of a significant multidirectional link between house prices, monetary variables and the macroeconomics; (2) the link between house prices and monetary variables is found to be stronger over a more recent sub-sample from 1985 to 2006; (3) the effects of shocks to money and credit are found to be stronger when house prices are booming.

Mian & Sufi (2009) conducted a US within-county analysis using detailed ZIP code-level data to identify consequences of mortgage credit expansion prior to the American Crisis. This research found that prior to the default crisis; these subprime ZIP codes experience an unprecedented relative growth in mortgage credit. The expansion in mortgage credit from 2002 to 2005 to subprime ZIP codes occurs despite sharply declining relative income growth in these neighborhoods. The authors state that in fact, 2002 to 2005 is the only period in the past eighteen years in which income and mortgage credit growth are negatively correlated.

Hwang (2009) proposes two dynamic regression models for the prediction of construction cost index. Comparison of the proposed models with the existing methods proves that the new models provide several advantages and improvements. The author concludes that is reasonable to assume that, as more construction activity occurs in the market, more resources are demanded. Naturally, more demand in capital, material and labor is likely to cause an increase in construction costs.

Adams & Fuss (2010) analyzed long term impact and short-term dynamics of macroeconomic variables on international housing prices and costs. They applied a panel co integration analysis consisting of 15 countries over a period of 30 years. This research does not confirm results from previous studies, but also allows for a comparison of single country estimations in an integrated equilibrium framework. The empirical results indicate long term effects of approximately 0,6% in construction costs in response to a 1% increase in economic activity. Full recovery from long term equilibrium may take up to 14 years.

Rosenfeld (2014) said that despite their negative impact on the construction industry, cost overruns have become an almost natural part of building and infrastructure projects. This research examines the phenomenon as a worldwide problem, identifies its root causes, ranks them on a local basis and analyses them. The main value of this paper to the global community of construction engineering and management is twofold: it identified 15 universal root causes of cost overruns, which provide a good starting point for any local investigation and offers a well-structured methodology for raking theses 15 universal root causes in accordance with the local circumstances. Among the mentioned 15 root causes are: premature tender documents and too many changes in owner´s requirements and definitions.

3 Time Series Co Integration and Granger Causality Methodologies

The stationary condition is the main requirement for time series analysis. The valid conditions of minimum squares are only valid in the presence of stationary time series Enders (1995). The unit root test was applied to check stationary conditions of data series in this research. The following series were used in this work: average construction cost per square meter, home credit, effective average income, cement consumption and construction materials sales. If a time series has unit root[2] then it is not stationary and the differentiation process[3] is required. In order to test the null hypothesis of unit root existence the Augmented Dickey-Fuller (ADF), where Ho represents $\delta = 0$, was applied. Besides ADF test, the Phillips-Perron test may be applied for the same objective.

Suppose Y_t e X_t time series I (1), stationary in first difference, the residues of equation (6) are also I (1), what is similar to say that those time series are not stationary in level.

$$Y_t = \alpha + \beta X_t + \varepsilon_t \quad (6)$$

According to Granger & Newbold (1986) there are some cases in which equation (6), for two I (1) time series, which may result in a stationary combination I (0). When this happen Y_t e X_t are so called co integrated or shows a long term balance. The co integration equation may be represented in (7) and β is the co integration parameter.

2 The unit root test shows the following model Yt=Yt-1 + ut, where ut is the stochastic error term that follow the Classical Hypothesis: zero mean, stable variance and is not correlated.

3 The new time series will have the following format: yt= yt – yt-1.

$$\varepsilon_t = Y_t - \alpha - \beta X_t = 0 \qquad (7)$$

According to Enders (1995) the most suitable test to detect time series co integration is the Johansen Test. The model proposed by Johansen (*apud* Kanas, 1998) uses trace and eigenvalue statistics in order to detect time series co integration existence. The Johansen Test proposes the following VAR specification model:

$$\Delta Y_t = \Pi Y_{t-1} + \Sigma \Gamma_t \Delta Y_{t-1} + \beta X_t + \varepsilon_t \qquad (8)$$

X_t, is the deterministic variable vector. According to Enders (1995), the critic point in the Johansen Test is to find the matrix Π rank. This rank r indicates the number of independent co integration vectors. So, if $r=0$, those time series are not co integrated. In case of $r=1$ this indicates 1(one) co integration vector between those time series. For those cases where $1 < r < n$, may happen multiple co integration vectors among time series.

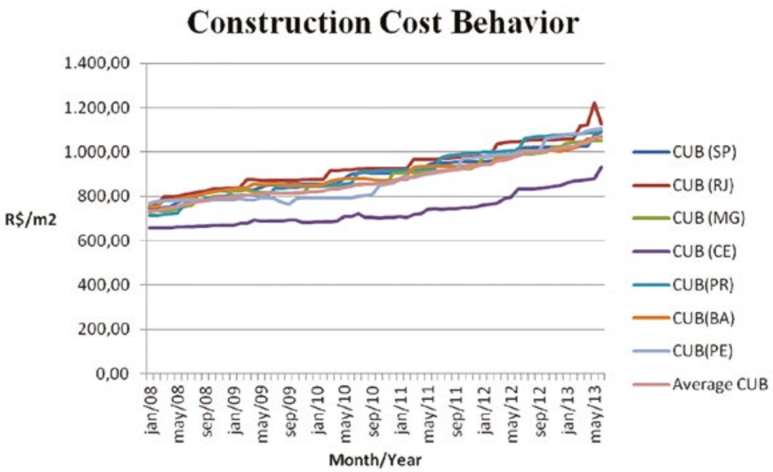
The Granger causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another. A time series *X* is said to Granger-cause *Y* if it can be shown, usually through a series of t-tests and F-tests on lagged values of *X* (and with lagged values of *Y* also included), that those *X* values provide statistically significant information about future values of *Y*.

If a time series is a stationary process, the test is performed using the level values of two (or more) variables. If the variables are non-stationary, then the test is done using first (or higher) differences. The number of lags to be included is usually chosen using an information criterion, such as the Akaike information criterion or the Schwarz information criterion. Any particular lagged value of one of the variables is retained in the regression if: it is significant according to a t-test and it and the other lagged values of the variable jointly add explanatory power to the model according to an F-test. Then the null hypothesis of no Granger causality is not rejected if and only if no lagged values of an explanatory variable have been retained in the regression, Enders (1995).

4 Empirical Results

The research data was collected from IPEADATA and SINDUSCON. This work used monthly data and covered the time span between January-2008 and June-2013. It was collected construction cost data (CUB) from seven selected Brazilian states in order to calculate the average Brazilian construction cost. The selected Brazilian states are as follows: São Paulo, Rio de Janeiro, Minas Gerais, Ceará, Pernambuco, Paraná e Bahia. Graph 1 shows the construction cost behaviour of each state together with its average.

Graph 1 – Construction Cost Behavior of Brazilian States



Source: Own research.

The following time series were collected with respective source:

a. Average Construction Cost per square meter (R$/m^2) – AVECUB. Source: SINDUSCON.

b. Home Credit (Millions R$) – CRE. Source: IPEADATA.

c. Effective Average Income (R$) – INCOME. Source: IPEADATA.

d. Cement Consumption – CIM (Tons). Source: IPEADATA.

e. Construction Materials Sales (2011 = 100) – CONSTRUMAT.

Source: IPEADATA.

The stationary condition was tested in all time series in order to make possible de application of the co integration test, Johansen Test. The co integration methodology is only applicable using time series not stationary in level. The ADF test was applied and the results are showed in Table 1.

Table 1 – Augmented Dickey-Fuller Test (ADF)

Time Series	Specification	Critical Values	ADF Statistics	Significance
AVECUB	Level	-2,6015	+10,0481	1%
CRE	Level	-2,6034	+0,5375	1%
INCOME	Level	-2,6027	+0,4076	1%
CIM	Level	-2,6076	+2,8332	1%
CONSTRUMAT	Level	-2,6061	+2,5418	1%

Source: Own research.

According to ADF Test all time series are not stationary in level what make appropriate the co integration analysis. The next step is to apply the Johansen Test between each variable to the average construction cost variable in order to identify which are cost determinant in the study region. Table 2 shows the results of the Johansen Test with trace and max eigenvalue test results.

Table 2 – Johansen Co Integration Test

Test	Vectors	Variable	Test Statistics	Critical Value (5%)	Probability
Trace	1	CRE	38,3019	20,2618	0,0001
Max Eigenvalue	1	CRE	34,9596	15,8921	0,0000
Trace	2	INCOME	26,7671	15,4947	0,0007
Max Eigenvalue	2	INCOME	20,5823	14,2646	0,0044
Trace	2	CIM	26,4609	12,3209	0,0001
Max Eigenvalue	2	CIM	18,3888	11,2248	0,0024
Trace	1	CONSTRUMAT	19,0159	12,3209	0,0033
Max Eigenvalue	1	CONSTRUMAT	14,9599	11,2248	0,0106

Source: Own research.

The co integration results show that all tested variables are co integrated to the average construction cost variable. These results demonstrate that all tested variables have a long term stable relationship with the average construction cost variable. Among those variables are cement consumption and construction materials sales variables. These variables may be a proxy of the Brazilian civil construction activity level. Moreover, the starting point for the Brazilian civil construction performance during the study period seems to be the increase in population´s income and more heavily due to the home credit availability.

In other words, population's income and home credit availability have induced the Brazilian civil construction activity as showed by cement consumption and construction materials sales behaviour. So, according to economic theory, when demand increases and supply does not increase in the same rate, a price increase is expected anytime in future. Therefore, Brazilian construction costs have increased in response to those variables behaviour.

In this research a Granger causality analysis between the time series variables is very suitable. Before applying this test it is essential to make sure that all variables are stationary. Above it is showed that all variables are not stationary in level; however by differentiating these variables the stationary condition is found. Table 3 shows the ADF results.

Table 3 – Augmented Dickey-Fuller Test (ADF)

Time Series	Specification	Critical Values	ADF Statistics	Significance
AVECUB	First Difference	-4,1104	-7,4709	1%
CRE	First Difference	-2,6027	-12,6331	1%
INCOME	First Difference	-2,6093	-15,0958	1%
CIM	First Difference	-2,6061	-5,5934	1%
CONSTRUMAT	First Difference	-2,6021	-12,5496	1%

Source: Own research.

After the stationary condition is reached the Granger causality test may be applied. The Granger causality investigation is relevant for this research because the results may explain the cause-effect chain into the Brazilian construction industry. In order to apply this test is crucial to find out how important the variable past is relevant to explain the present. For this purpose a lag length criteria should be observed. Using the Schwarz criteria the optimum lag number is 2 (two) as showed in table 4.

Table 4. Lag Length Criteria

Lags	Schwarz Criteria
0	78,6497
1	69,5814
2	69,1060*
3	69,6526
4	70,1382
5	70,7386

Source: Own research.

In Table 5 the Granger causality results among the research variables are showed. It is clear that INCOME has a bi-directional relationship with CRE. The credit variable, CRE also has a bi-directional relationship with AVECUB. The INCOME variable induces positively CIM and CONSTRUMAT variables, however does not induce the AVECUB variable directly. The CRE variable also induces positively the CIM and CONSTRUMAT variables and mainly the AVECUB variable.

What can be accepted from the results is that an increase in the population's income has fostered the Brazilian civil construction activity trough cement consumption and construction materials sales. Moreover, a raise in population's income has provoked an increase in home credit availability offered by Brazilian banks. Credit offer is generally based on income ratings. The home credit availability has enhanced the population purchase power and also provoking an increase in cement consumption and also construction materials sales. However, the major impact from home credit was in the construction cost.

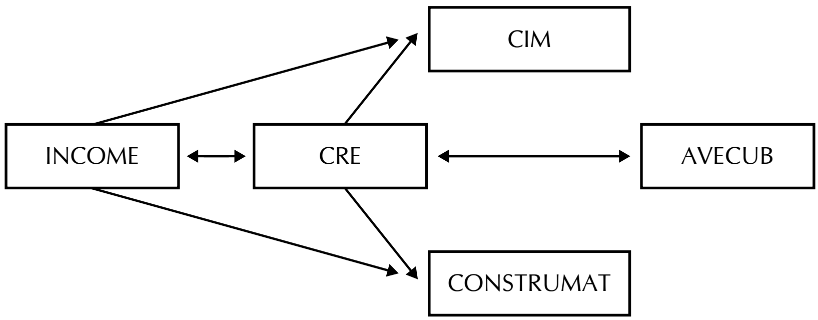
Table 5 – Granger Causality Test

Variable	Causality	Variable	p-Value F Test	Comments
INCOME	⟶	CRE	0,0102	Strong effect
INCOME	⟶	CONSTRUMAT	0,0092	Strong effect
INCOME	⟶	CIM	0,0145	Strong effect
INCOME	⟶	AVECUB	0,1972	No effect
CRE	⟶	CIM	0,0768	Strong effect
CRE	⟶	CONSTRUMAT	0,0331	Strong effect
CRE	⟶	INCOME	0,0023	Strong effect
CRE	⟶	AVECUB	0,0010	Strong effect

Source: Own research.

According to Granger causality results the key impact variable is home credit. That is curious the fact that an increase in population's income alone does not impact construction costs. Due to the Brazilian population low savings ratio, home credit became very relevant for improving civil construction activity. Figure 1 represents graphically the cause-effect relationship above specified.

Figure 1 – Construction Variables Behavior Flowchart



Source: Own research.

The above flowchart clarifies Brazilian civil construction variables relationship. The American Crisis has forced the Brazilian government to employ macroeconomic measures in order to overcome its economic impacts. Higher liquidity level, drastic reduction of interest rates, reduction of compulsory deposits by commercial banks, raise in credit availability and specifically the government low income housing program called *"Minha Casa Minha Vida"*, have made tremendous encouraging conditions for the civil construction industry.

Major Brazilian states were chosen in order to identify construction cost behavior across the research period. The results are amazing due to the fact that states from the south and southeast of Brazil tend to have a higher increase in construction cost. On the other hand states from northeast and west of Brazil tend to have a lower raise in construction cost. In average Brazilian construction costs have increased not less than 45,81% across the research period. Table 6 shows construction cost variations along the major Brazilian states selected. The highest construction cost per square meter was detected in Rio de Janeiro and the lowest in Ceará. The highest variation was detected in Paraná and the lowest also in Ceará. In parenthesis on the right hand side of all figures there is the state place.

Table 6 – Construction Cost Variations

State	CUB (R$/M2) Jan/2008	CUB (R$/M2)June/2013	% Variation
São Paulo	744,86 (4o)	1089,49 (4o)	46,27 (3o)
Rio de Janeiro	753,29 (3o)	1125,01 (1o)	49,35 (2o)
Minas Gerais	729,11 (5o)	1049,84 (6o)	43,99 (5o)
Ceará	657,02 (7o)	930,00 (7o)	41,55 (7o)
Paraná	712,85(6o)	1089,82 (3o)	52,88 (1o)
Bahia	753,50 (2o)	1072,23 (5o)	42,30 (6o)
Pernambuco	767,87 (1o)	1106,73 (2o)	44,13 (4o)
Average	**731,21**	**1066,16**	**45,81**

Source: Own research.

In São Paulo, Rio de Janeiro and Paraná this research detected construction cost variations above average. In Ceará, Pernambuco, Bahia and Minas Gerais this work on the other hand detected construction cost variations below average. Variations on other research variables were also remarkable. Home credit availability increased about 523,71%, cement consumption increased about 36%, construction materials sales increased over 78% and income has increased 15,16%.

5 Final Remarks

This academic work investigated Brazilian cost behavior between the periods of January/2008 until June/2013. The time series co integration and Granger causality approaches were applied. Research data was collected from IPEADATA and SINDUSCOM.

The results obtained indicate that all research variables are co integrated with average construction cost variable. In other words, all research variables have long term stable relationship with average construction cost variable. In the Granger causality test, there is a strong link among all variables. However, population´s income does not cause average construction cost alone. The results suggest that the home credit variable which has a bi-directional relationship with population´s income is the key variable for average construction cost behavior.

Across the research period home credit has raised over 523% and population´s income about 15%. The results suggest that due to this relevant boost in home credit availability; cement consumption and construction material sales have increased more heavily. As indicators of civil construction activity level, cement consumption and construction material sales, showed how the Brazilian civil construction sector was affected by home credit policy. In consequence of this behavior, average construction cost was heavily affected across all selected Brazilian states.

This research confirms Hwang (2009) with respect demand and supply movements which interfere in construction cost behavior. The results also confirm research carried out by Adams & Fuss (2010) in which construction costs are influenced heavily by economic activity increase. Edelstein & Tsang (2007) academic work was also confirmed by this research when employment growth or population's income is recognized as a key determinant of residential real estate sector. Mian & Sufi (2009) assumed, as in this research that credit growth should be positively correlated to income. They also identified that from 2002 to 2005, is the only period in the past eighteen years in which income and mortgage credit growth are negatively correlated, provoking the starting point for sub-prime crisis in US.

Goodhart & Hofmann (2008) results are also confirmed by this academic work when it is assumed that home credit shocks are particularly sensitive in residential housing market. This research confirms Santos & Cruz (2000) work when income has a strong correlation to real estate demand and indirectly to construction costs. Chan (1999) concludes, as in this research, that credit market is particularly important to residential construction.

Conclusively the Brazilian construction cost behavior was affected by all selected variables in different ways; however the key variable for this performance was home credit availability. Home credit has forced a raise in real estate demand that influenced heavily in construction cost increases. Results also suggest that the construction cost behavior was different across the selected Brazilian states.

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